

## **Dynamic Planet C**

**BirdSO Mini, December 2021**

**Directions:**

- You will have 50 minutes for the entire event.
- You may use a binder, but this test is **not** open internet. It is recommended that you have a calculator.
- This test is worth 148 points. Try to complete as much of the event as possible.
- There are 10 sections with questions of varying topics and difficulty. It is recommended to look through all sections.
- The point value of “select all that apply” questions may or may not be equal to the number of correct answers.
- Tiebreakers are marked in the test in the order they will be broken (e.g., “TB1” is the first tiebreaker, “TB2” the second, etc.)

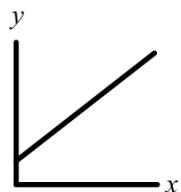
## Section 1: Multiple Choice/Multiple Select (37 pts)

Multiple choice questions are 1 pt each. Multiple select (“select all that apply”) questions are 2 pts each, and may have one or more than one correct answer.

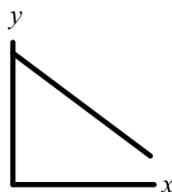
1. Rank the average particle size of the following stream loads from smallest to largest.

- 1 - bed load
  - 2 - suspended load
  - 3 - dissolved load
- a. 1, 2, 3
  - b. 1, 3, 2
  - c. 2, 1, 3
  - d. 2, 3, 1
  - e. 3, 1, 2
  - f. 3, 2, 1

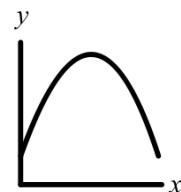
2. Which of the following graphs, if any, best shows the relationship between the radius of sediment particles versus increasing depth in the middle of a lake?



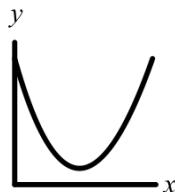
(A)



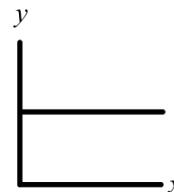
(B)



(C)



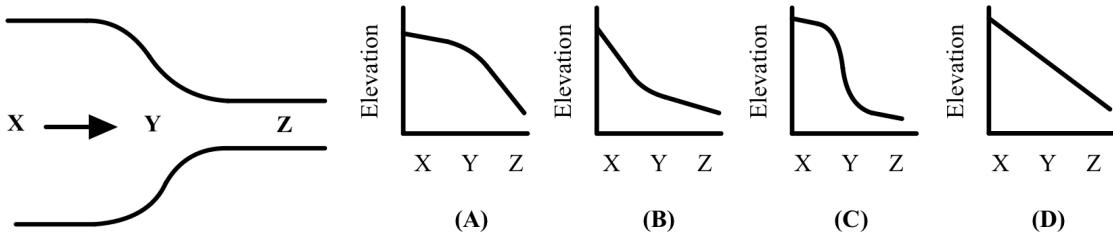
(D)



(E)

- a. A
- b. B
- c. C
- d. D
- e. E
- f. No distinct relationship; lake deposits are often poorly sorted

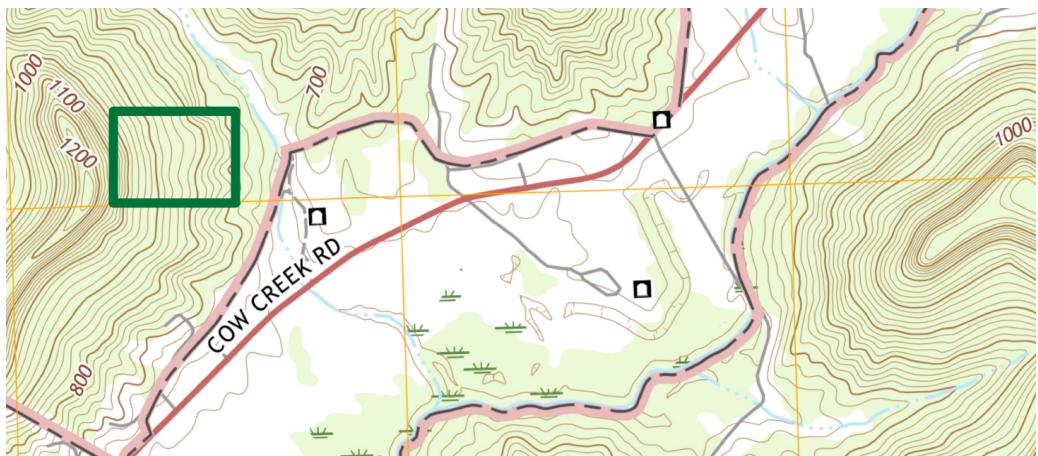
3. [TB9] Consider the following map view of a river (arrow shows flow direction) with labeled points X, Y, and Z. Four possible profiles are shown.



Which topographic profile is the most accurate? Assume uniform discharge in the river.

- a. A
  - b. B
  - c. C
  - d. D
4. [TB12] Consider a hypothetical drainage system in which all first-order tributaries have identical discharges of  $100 \text{ m}^3/\text{s}$ . Which best describes the discharge at the start of a third-order stream (i.e., the point of a third-order stream closest upstream)? (Use Strahler stream order)
- a. Equal to  $300 \text{ m}^3/\text{s}$
  - b. At least  $300 \text{ m}^3/\text{s}$
  - c. At most  $300 \text{ m}^3/\text{s}$
  - d. Equal to  $400 \text{ m}^3/\text{s}$
  - e. At least  $400 \text{ m}^3/\text{s}$
  - f. At most  $400 \text{ m}^3/\text{s}$
5. Which of these conditions is most likely to result in a decrease in delta size?
- a. Increased upstream precipitation and regional uplift
  - b. Increased upstream precipitation and regional subsidence
  - c. Decreased upstream precipitation and regional uplift
  - d. Decreased upstream precipitation and regional subsidence

For questions 6-8, refer to the following topographic map. Assume the top of the map is north.



(credit: section of USGS Irvine KY Quadrangle)

6. What type of stream is featured in the map?
  - a. Perennial stream
  - b. Disappearing stream
  - c. Intermittent stream
  - d. Underground stream
  - e. Rapids
7. What type of wetland, if any, is featured in the map?
  - a. Submerged marsh or swamp
  - b. Wooded marsh or swamp
  - c. Marsh or swamp (not submerged or wooded)
  - d. No wetlands are featured
8. What is the most likely direction of groundwater flow within the green boxed area?
  - a. Towards the north
  - b. Towards the east
  - c. Towards the south
  - d. Towards the west

9. Some relatively sinuous river systems experience a sudden decrease in sinuosity. What is the most likely cause for this occurrence?
- Sudden changes in discharge, such as flooding
  - Earthquakes and tectonic events, resulting in sag pond formation
  - Landslides blocking river flow, forming a natural dam
  - Formation of oxbow lakes due to streamflow changes
  - Tendency for more mature streams to straighten
10. Which of the following sediment types would have the greatest porosity to permeability ratio (porosity / permeability)?
- cobbles
  - clay
  - silt
  - sand
  - gravel
11. Which of the following correctly lists water reservoirs in order of increasing percentage of Earth's total water?
- Glaciers and ice caps < Lakes < the Atmosphere < Oceans
  - Glaciers and ice caps < the Atmosphere < Lakes < Oceans
  - Lakes < the Atmosphere < Glaciers and ice caps < Oceans
  - Lakes < Glaciers and ice caps < the Atmosphere < Oceans
  - The Atmosphere < Lakes < Glaciers and ice caps < Oceans
  - The Atmosphere < Glaciers and ice caps < Lakes < Oceans
12. Which of the following correctly lists water reservoirs in order of increasing percentage of Earth's fresh water?
- Rivers and streams < Lakes < Permafrost < Glaciers and ice caps
  - Rivers and streams < Permafrost < Lakes < Glaciers and ice caps
  - Lakes < Rivers and streams < Permafrost < Glaciers and ice caps
  - Lakes < Permafrost < Rivers and streams < Glaciers and ice caps
  - Permafrost < Rivers and streams < Lakes < Glaciers and ice caps
  - Permafrost < Lakes < Rivers and streams < Glaciers and ice caps

For questions 13 and 14, refer to the following satellite image labeled with two locations, X and Y.



(credit: satellite image of Canyonlands National Park taken by Landsat 7 ETM+)

13. Location X is at a(n) \_\_\_\_ elevation compared to Location Y.
- Higher
  - Lower
  - Equal
  - Cannot be determined
14. Which of the following statements are true regarding the process occurring near Location X?
- The process shortens the stream channel
  - The process lengthens the stream channel
  - The process is dominated by erosion
  - The process is dominated by deposition
15. Hack's law states that the length of the longest stream in a basin can be approximated by  $L = CA^h$ , where L is the length of the longest stream, A is the area of the basin, and C is some constant. Assuming the exponent h to be 0.6, how many times its original length would the longest stream in a basin be if the area of the basin doubled?
- 0.660
  - 0.737
  - 1.516
  - 2.000

16. Large forest fires can impact a region's hydrology significantly. Select all of the following statements that are true regarding their impacts.

- a. Reduction in overland flow during heavy rain events
- b. Reduction in soil moisture
- c. Reduction in infiltration capacity
- d. Reduction in transpiration rate

17. A well begins pumping groundwater at a uniform rate  $q_1$  for time  $t$ . If the pumping rate decreases to a new uniform rate  $q_2 < q_1$  for another time interval  $t$ , which of these best describes what will happen to the cone of depression? (Assume no recharge and uniform soil)

- a. An increase in its depth and a decrease in its slope
- b. An increase in its depth and a decrease in its radius
- c. An increase in its slope and a decrease in its depth
- d. An increase in its radius and a decrease in its depth

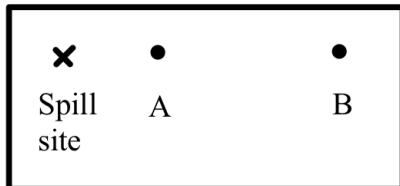
18. Which of the following correctly matches the lake to its type?

- a. Lake Baikal, tectonic lake
- b. Lake Agassiz, glacial lake
- c. Crater Lake, volcanic lake
- d. All of the above

19. Select all of the following statements that are true regarding the hydrograph for a region after it is urbanized.

- a. A larger proportion of rainwater infiltrates the ground compared to pre-urbanization
- b. A smaller proportion of rainwater infiltrates the ground compared to pre-urbanization
- c. The peak discharge after rainfall is greater compared to peak discharge pre-urbanization
- d. The peak discharge after rainfall is lower compared to peak discharge pre-urbanization
- e. The lag time between rainfall and discharge is longer compared to the lag time pre-urbanization
- f. The lag time between rainfall and discharge is shorter compared to the lag time pre-urbanization

20. A chemical spill happens instantaneously in a localized region marked by the X on the map. The edge of the plume reaches site B at  $t = 10$  min after the spill. Select all of the following statements which are likely true. (Note:  $A_{10}$  = concentration of pollutant at site A at time  $t = 10$  min)



- a.  $A_{10} > B_{10}$
  - b.  $A_{10} = B_{10}$
  - c.  $A_{10} < B_{10}$
  - d.  $A_{10} > A_{30}$
  - e.  $A_{10} = A_{30}$
  - f.  $A_{10} < A_{30}$
21. Which of these can be generally assumed about the rate of pollutant transport at 10 m below the surface,  $v_{10}$ , and at 50 m below the surface,  $v_{50}$ ?
- a.  $v_{10} > v_{50}$
  - b.  $v_{10} = v_{50}$
  - c.  $v_{10} < v_{50}$
  - d. Inconclusive; the rates vary widely by region
22. [TB3] Consider the data table below. Each well is located at 125 m above sea level.

Well	A	B	C	D
Height of piezometric surface (m above sea level)	150	100	150	100
Confined aquifer?	Yes	Yes	No	No

Which well is considered an artesian well?

- a. A
- b. B
- c. C
- d. D

23. The table below describes the vegetation found at three locations.

Location	Vegetation
X	cypress trees, buttonbush shrubs, cattails
Y	sphagnum moss, water chestnut sedge, pitcher plants
Z	sawgrass, cattails, papyrus sedge

Which of the following correctly classifies the three locations?

- a. X - bog, Y - marsh, Z - swamp
- b. X - bog, Y - swamp, Z - marsh
- c. X - marsh, Y - bog, Z - swamp
- d. X - marsh, Y - swamp, Z - bog
- e. X - swamp, Y - bog, Z - marsh
- f. X - swamp, Y - marsh, Z - bog

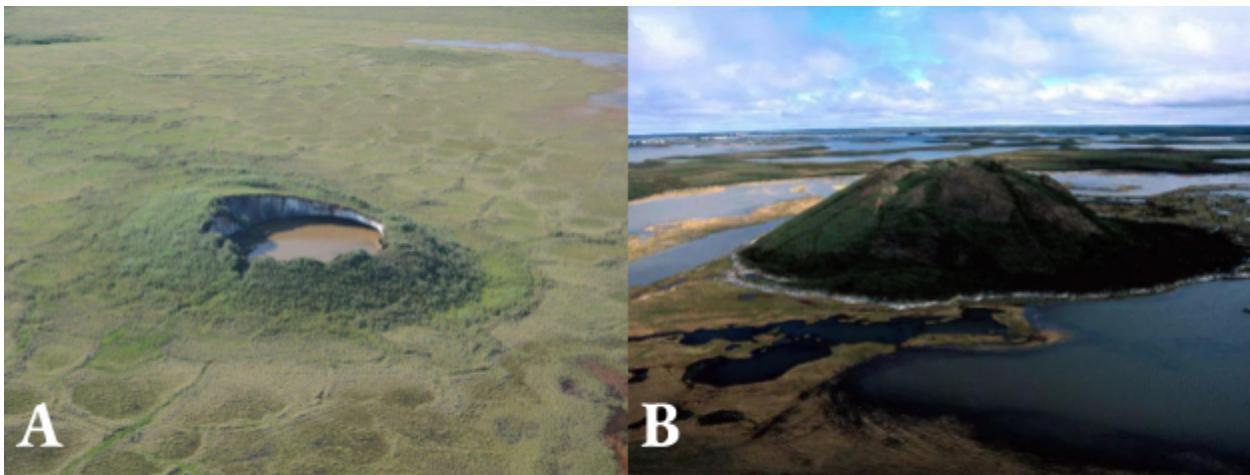
24. Select all of the following statements that are true regarding bogs.

- a. Bogs derive the majority of their water from surface water
- b. Bogs derive the majority of their water from groundwater
- c. Water flowing from bogs tends to be brown due to high peat tannin concentrations
- d. Bogs are eutrophic
- e. Bogs are oligotrophic
- f. Bogs are ombrotrophic

25. Select all of the following statements that are true regarding freshwater marshes.

- a. They are often found in high elevation areas
- b. They are characterized by moist, well-oxygenated soils
- c. They reduce the variability of adjacent streamflow
- d. Some freshwater marshes are subject to cyclic changes in water levels
- e. Diversion of water by artificial canals can lead to their decline

For questions 26 and 27, use the following images.



26. Image A and Image B represent two different stages for this feature. Which of the following correctly states the order that these stages occur and a reasonable month of the transition event?

- a. The stage in Image A transitions into the stage in Image B during January
- b. The stage in Image B transitions into the stage in Image A during January
- c. The stage in Image A transitions into the stage in Image B during July
- d. The stage in Image B transitions into the stage in Image A during July
- e. The stage in Image A transitions into the stage in Image B during November
- f. The stage in Image B transitions into the stage in Image A during November

27. Select all of the following statements that are true regarding the feature in this image.

- a. The feature forms when the soil temperature remains below 0\degree C
- b. The feature forms when the soil temperature remains below 32\degree C
- c. The open system type of this structure is found in areas with a substantial groundwater source
- d. The closed system type of this structure is found in areas with a substantial groundwater source
- e. The high specific heat of water is directly related to the formation of these features
- f. The expansion of water at low temperatures is directly related to the formation of these features

28. Which of the following statements regarding speleothems is incorrect?
- Stalactites hang from the ceilings of caverns
  - Caverns with speleothems occur within the saturated zone
  - Columns form when a stalagmite combines with a stalactite
  - Stalagmites have a hollow structure
  - None of the above (all statements are correct)
29. Which of the following incorrectly matches the fluvial terrace type to its description?
- Strath terraces form when a stream downcuts through bedrock
  - Unpaired terraces are terraces that exist on opposite sides of a river but are at the same elevation
  - Nested fill terraces form when a previously filled valley is eroded and refilled with less sediment
  - Fill terraces form when a valley is filled with river sediment
30. Which of the following pollution sources can be considered geogenic?
- Road salt causing high chloride concentrations in water bodies
  - Excessive fertilizer use causing high nitrate concentrations
  - Uranium in bedrock decaying to release radon
  - Leachate from landfills seeping into aquifers
  - Improperly designed septic tanks allowing bacteria to enter groundwater

## Section 2: The Hydrologic Cycle and Water Budgets (12 pts)

31. (2 pts) Select all of the following true statements about the hydrologic cycle.
- a. The amount of water vapor in the atmosphere over a given region remains constant.
  - b. Due to global warming, the hydrologic cycle is slowing down.
  - c. The formation of fog over a warm lake is an example of evaporation.
  - d. Out of all precipitation falling on Earth's surface, most falls onto the oceans.
  - e. Energy from the Sun is the only major source of energy driving the hydrologic cycle.
  - f. During periods of light rain, it is possible for there to be zero runoff.

32. (3 pts) [TB5] Is the net seaward flux (towards the sea) of atmospheric water vapor positive, negative, or zero? Justify your answer.

Suppose you are hiking on a tall, snowy mountain and notice that a snowfield has shrunk noticeably in size in the past few hours with very little meltwater.

33. (0.5 pt) Identify the process in the water cycle responsible for this observation. (Hint: what happened to the snow that didn't melt?)

34. (0.5 pt) Indicate whether the process involves an absorption of heat energy, a release of heat energy, or neither.

- a. absorption of heat energy
- b. release of heat energy
- c. neither

Water budgets can be used to model the hydrologic characteristics of a region. Let  $P$  = precipitation,  $ET$  = evapotranspiration,  $R$  = runoff, and  $I$  = infiltration.

35. (1 pt) For the hydrologic cycle on Earth overall, select all of the below expressions that correctly compare the quantities above.

- a.  $P > (R + I)$
- b.  $(R + I) > ET$
- c.  $ET > I$
- d.  $(ET + R) > P$

36. (1 pt) In terms of  $P$ ,  $R$ , and  $I$ , write an expression equivalent to the fraction of precipitation that undergoes evapotranspiration.

A researcher models annual lake volume fluctuations of an ephemeral lake. Assume the lake is not connected to any surface streams. In the model, precipitation  $P$  and evaporation  $E$  (calculated in L/h) are assumed to be the only inputs and outputs, respectively, to the lake.

37. (2 pts) [TB11] The researcher wants to find the change in lake volume  $\Delta V$  over time by graphing. What quantity should be plotted on the  $y$ -axis vs. time, and how can the graph be used to find  $\Delta V$ ?
38. (2 pts) Are the actual lake levels likely to be higher, lower, or approximately equal to the modeled lake levels? Briefly justify your answer.

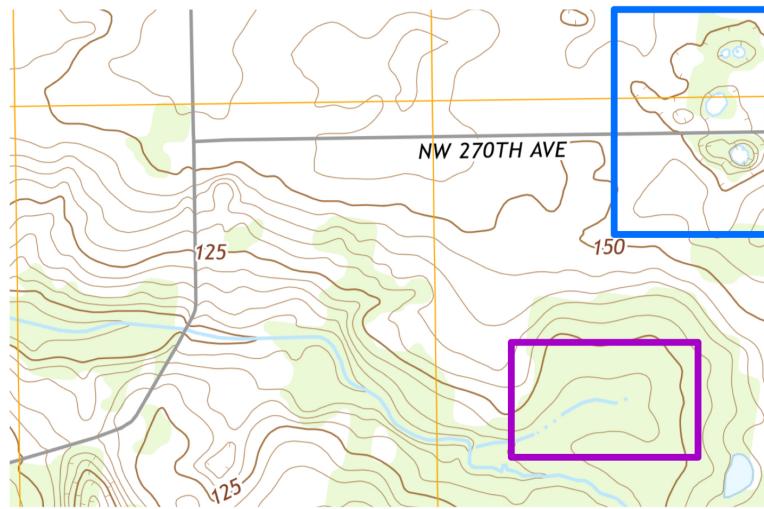
## Section 3: Floods and land use (10 pts)

39. (2 pts) Flood safety is important! Identify all of the following true statements, if any.
- a. It is generally safe for a car to pass through a foot of flowing water.
  - b. Flash flooding is generally more likely to occur in fields than urbanized surfaces.
  - c. A few inches of rain can raise the stream level by a few feet or more.
  - d. Floodwaters are not safe to consume due to hazardous contaminants that may be present.
  - e. None of these are true.
40. (2 pts) [TB4] A 25-year flood occurred in a town in 2021. Based on the information, which of the following statements is/are true about flooding risk in that town, if any?
- a. The next 25-year flood will not occur until 2046.
  - b. The next 25-year flood is expected to occur before 2046.
  - c. Multiple 25-year floods can occur before 2046.
  - d. It is possible for a flood of the same severity to be classified as a 10-year flood in the future
  - e. None of these are true.
41. (2 pts) Based on the previous question, calculate the probability (to the nearest percent) of a 25-year flood in the period 2022 to 2026. Show relevant equation(s) and calculation steps.
42. (2 pts) Studies have mixed results regarding the effect of urbanization on base flow volume. Select all of the following that would support the hypothesis that base flow decreases due to urbanization.
- a. Some cities have higher rates of water consumption than surrounding areas.
  - b. Vegetative cover is associated with significant evapotranspiration in an area.
  - c. In a certain region, it is found that a high proportion of base flow is sourced directly from groundwater.
  - d. Discharge from urban streams is found to be higher than that from non-urban streams during periods of no precipitation.
43. (2 pts) Some fish species lay their eggs in sediment. Briefly describe how artificial channels affect the stream and reduce their survivability.

## Section 4: Karst hydrology (12 pts)

44. (3 pts) [TB2] Let  $q_{\text{surf}}/q_{\text{sub}}$  be defined as the ratio of surface discharge to subsurface discharge. Is it expected for a karst region to have a high or low value of  $q_{\text{surf}}/q_{\text{sub}}$  relative to non-karst regions? Identify a common karstic rock type, then briefly describe how a property of the rock relates to your answer to the first question.

For questions 45-46, consider the topographic map below. Assume the top of the map is north.



(credit: section of USGS Mikesville FL Quadrangle)

45. (2 pts) What karstic features are located in the blue box? What is the meaning of the USGS topographic map symbols used to depict these features? (Hint: They are different.)
46. (2 pts) A student claims that the feature in the purple box is a disappearing stream. Is the student correct? Briefly discuss the evidence in the map that led to your answer and state the direction of flow, if any, of the feature.
47. (1 pt) Suppose the • symbol were present near the easternmost end of the feature. Would that suggest the presence of an underground stream? Interpret the meaning of the symbol.
48. (2 pts) What hazard besides pollution could groundwater withdrawal pose in a karst region? Briefly describe one way withdrawing groundwater could lead to this hazard.

49. (1 pt) In a karst region, an empty cavern is located in the zone of \_\_\_\_ and indicates a water table that was previously \_\_\_\_ than the present.

- a. aeration; higher
- b. aeration; lower
- c. saturation; higher
- d. saturation; lower

50. (1 pt) Which of these chemical properties is characteristic of karstic lakes?

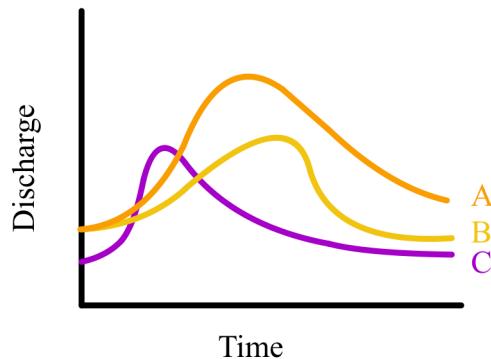
- a. High salinity
- b. Low salinity
- c. High alkalinity
- d. Low alkalinity

## Section 5: Going with the flow (15 pts)

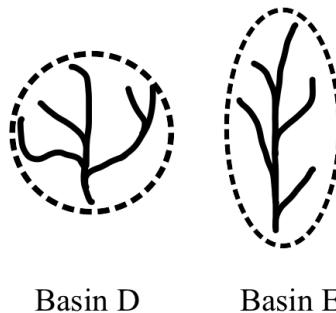
Hydrographs can be used to model stream flow by plotting discharge versus time.

51. (2 pts) Refer to the sample hydrographs shown below. A brief downpour occurs at  $t = 0$ .

Which hydrograph (A, B, or C) is least realistic? Briefly justify your answer.



The two drainage basins shown (D and E) have equal areas and similar characteristics; they differ only in their shape (shown by the dotted outlines). Assume that a rainstorm drops the same amount of precipitation across both basins.



Basin D              Basin E

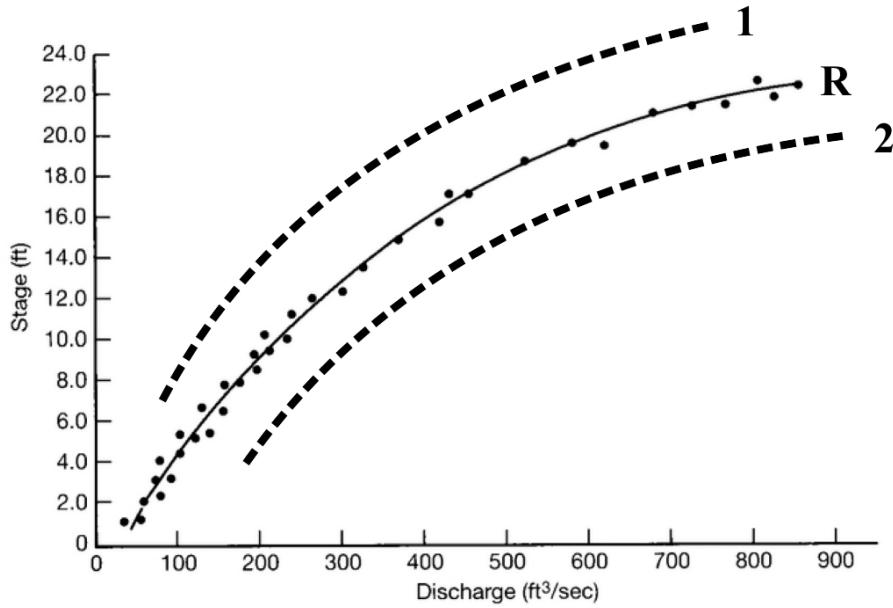
52. (1 pt) Which basin will have a longer lag time?

- a. Basin D
- b. Basin E
- c. Neither

53. (1 pt) Which basin will have a higher peak on its hydrograph?

- a. Basin D
- b. Basin E
- c. Neither

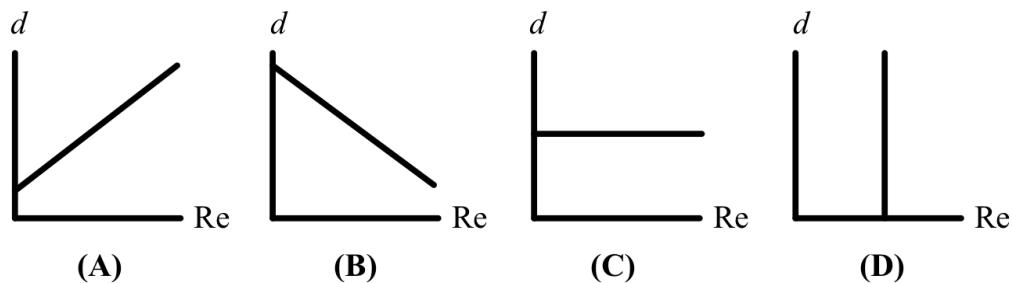
Rating curves, graphs of stage versus discharge, can also be used to model stream flow. Stage is the water level measured from some arbitrary reference point.



(adapted from Sanders 1998)

54. (1 pt) Consider the solid curve labeled “R.” At a stage of 12 ft, what is the approximate discharge, in ft<sup>3</sup>/s, of the stream?
55. (2 pts) [TB1] If the stream’s width increases, and all else remains equal, would curve 1 or curve 2 represent the new curve? Briefly justify your answer.

The Reynolds number (Re) is a dimensionless quantity proportional to flow speed. In an area, there is a correlation between the Re of a river and the depth to the water table  $d$  in a nearby well.



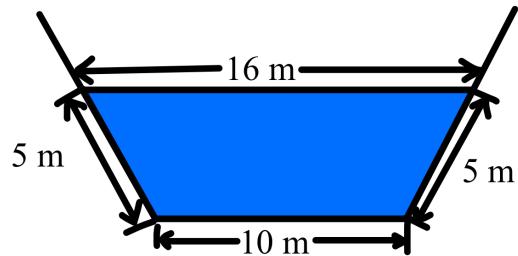
56. (1 pt) Select the graph above that best describes the relationship.
- A
  - B
  - C
  - D

57. (2 pts) [TB8] Explain your answer to the previous question. (Hint: State one variable that affects both  $d$  and  $Re$ , and briefly discuss how that variable affects  $d$  and  $Re$ .)

58. (1 pt) Does turbulent flow increase, decrease, or have no effect on the average stream velocity compared to laminar flow?

- a. Increase
- b. Decrease
- c. No effect

59. (4 pts) [TB6] Consider the following cross-section of a stream (assume that it is symmetric). Given a Manning's roughness coefficient of  $n = 0.03$  and a slope of  $1/25$  (perpendicular to the cross section), calculate the discharge of the stream. Show relevant equation(s) and calculation steps.



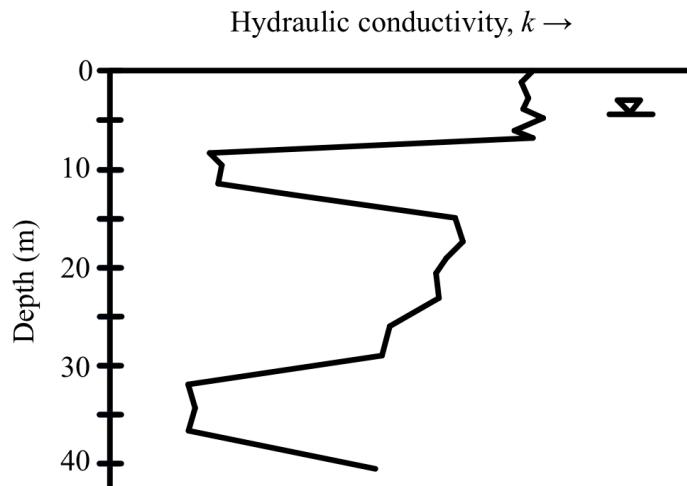
## Section 6: Groundwater Day (11 pts)

Consider the data table below.

	Well A	Well B
Elevation (above mean sea level) (m)	130	110
Depth to water table (m)	15	5

60. (3 pts) [TB10] The walking distance from Well A to Well B is 50 m. Calculate the magnitude of the hydraulic gradient from well A to well B, rounding to the nearest hundredth. Show relevant equation(s) and calculation steps.
61. (2 pts) Well A is located west of Well B, which is located west of a stream. Based on the data in the table, is the stream classified as influent (losing), effluent (gaining), or neither? Justify your answer.

Shown below is a graph of depth vs. hydraulic conductivity (increasing values towards the right) for another well. The inverted triangle denotes the level of the water table. Use the graph for questions 3-4.



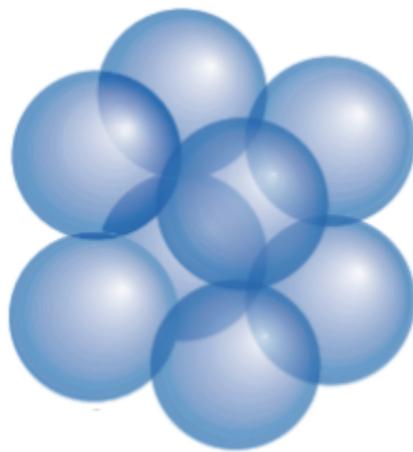
62. (2 pts) Select all of the following that can be reasonably concluded from the graph above.

- a. A confining bed exists between the depths of 0 and 5 m.
- b. A confining bed exists between the depths of 7 and 15 m.
- c. A perched aquifer exists between the depths of 0 and 7 m.
- d. A perched aquifer exists between the depths of 7 and 15 m.
- e. Assuming that the hydraulic gradient is constant, depth vs. groundwater velocity would mirror depth vs. hydraulic conductivity.
- f. Assuming that the hydraulic gradient is constant, depth vs. porosity would mirror depth vs. hydraulic conductivity.

63. (1 pt) To which depth should a well reach to maximize yield and to minimize potential for contamination?

- a. 5 m
- b. 10 m
- c. 20 m
- d. 35 m

64. (3 pts) The porosity of a rock can be expressed by the equation  $\phi = \frac{V_{void}}{V_{total}}$ . Use this equation to derive the porosity of the cubic packing arrangement shown below. Show relevant equation(s) and calculation steps. Round your answer to the nearest thousandth.



## **Section 7: BirdSO meets freshwater (12 pts)**

65. (2 pts) According to a study, river-obligate bird species “were associated significantly with the least modified reaches characterized by faster flows, exposed bedrocks, banks with pebbles, [and] boulders with more intact riverine forests” (Sinha et al. 2019). Based on this information, in which areas are river-obligate bird species likely found? Select all that apply.

- a. Areas with extensive natural levees
- b. Areas with relatively straight stream channels
- c. Areas with relatively wide stream channels
- d. Areas with a high-energy depositional environment

The Great Lakes are home to many bird species. Lake levels in the Great Lakes vary on a seasonal and multiannual basis.

66. (2 pts) In the winter, the Great Lakes are regularly subject to sub-freezing air temperatures.

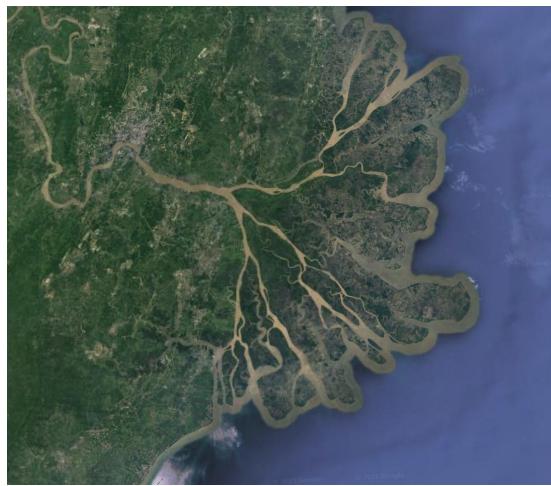
Predict the effect that lower than average winter temperatures would have on lake levels. Briefly justify your answer.

67. (1 pt) Another study (Reske and Yun 2000) found that water levels in the Great Lakes were inversely related with bird species diversity and habitat availability. What effect would above-average winter snowfall alone have on total shoreline diameter and bird species diversity in the following spring?

- a. Increase; increase
- b. Increase; decrease
- c. Decrease; increase
- d. Decrease; decrease

68. (2 pts) A student hypothesizes that dam construction on streams emptying into the Great Lakes would decrease bird species diversity. Briefly explain whether the student’s hypothesis is justified, and include the term “base level” in your explanation.

Refer to the following image of a delta for questions 69-72.



(Credit: Google Earth)

(0.5 pt each) Based on the image, indicate whether each of the following statements is true or false.

69. The delta can be classified as a “bird foot” delta
70. The delta likely consists of highly angular sediment
71. The smaller streams that the main branch separates into are termed tributaries
72. The delta is a hybrid between river-dominated and tide-dominated

Ducks and geese commonly inhabit wetlands and lakes. However, they can affect the chemical properties of lakes, and they may be negatively affected if their habitats are polluted.

73. (1 pt) Ducks and geese are introduced to a lake and their populations increase. In what ways will this change the lake? Select all that apply.
  - a. Overall dissolved oxygen levels in the lake will decrease.
  - b. Overall phosphorus levels in the lake will decrease.
  - c. If the lake were initially mesotrophic, the lake may become eutrophic.
  - d. If the lake were initially eutrophic, the lake may become mesotrophic.

74. (2 pts) Heavy metal contamination of lakes is a significant issue. Select all of the following that are true about heavy metal contamination.
  - a. High microplastic concentrations may enhance heavy metal pollution
  - b. Heavy metals can be deposited onto surface waters from the atmosphere
  - c. Heavy metals can be transported via dissolved load as well as via suspended load
  - d. Heavy metals are nearly solely sourced from human-related activities
  - e. Lakes with higher pH are more susceptible to heavy metal pollution
  - f. Increased lake conductivity may be associated with higher heavy metal concentrations

## **Section 8: Everyone should lake hydrology (18 pts)**

A lake is located in a region with average air temperatures (in °C) of select months shown in the data table below.

Month	January	April	July	October
Avg. high	9	18	28	19
Avg. low	2	9	19	11

75. (1 pt) Which is the most likely classification for the lake?

- a. Warm monomictic
- b. Cold monomictic
- c. Dimictic
- d. Polymictic
- e. Amictic

76. (1 pt) During which month(s) is the thermocline most pronounced? Select all that apply.

- a. January
- b. April
- c. July
- d. October

77. (1 pt) During which month(s) is lake turnover most likely to occur? Select all that apply.

- a. January
- b. April
- c. July
- d. October

The following figures show some possible lake setups; the ovals represent the lake bodies and the arrows represent surface streams flowing into/out of the lake.



Figure A



Figure B



Figure C



Figure D

78. (1 pt) Which figure(s) correspond to an endorheic lake? Select all that apply.

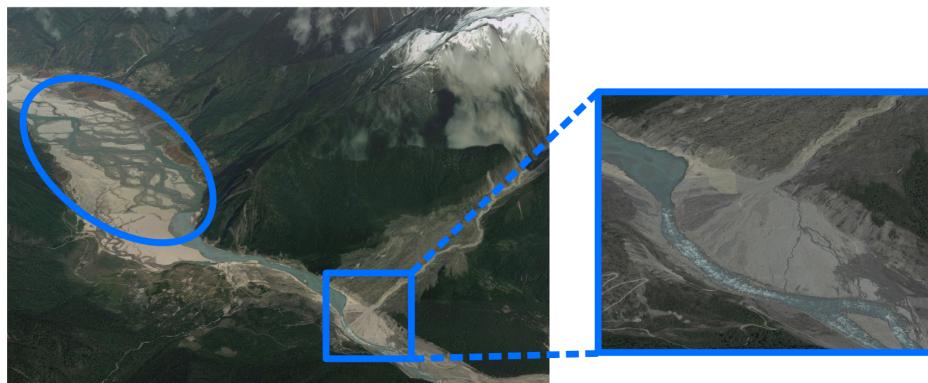
- a. A
- b. B
- c. C
- d. D

79. (1 pt) Which figure is the most common?

- a. A
- b. B
- c. C
- d. D

80. (2 pts) Which figure best corresponds to a perennial lake located in a region with uniformly impermeable bedrock? Justify your answer.

The figure below shows the site of a former lake, circled in the photo below.



81. (1 pt) How was this lake probably formed? (A word or phrase is enough)

82. (1 pt) What is the channel type encircled in the blue ellipse? (please answer with one word)

83. (1 pt) Identify the feature that is boxed.

Lakes have multiple physical and chemical properties.

84. (2 pts) Select all the following statements that are true about light levels in a lake.

- a. During the summer, the average intensity of light in a lake is higher.
- b. Light levels generally decrease linearly with depth.
- c. Light availability in lakes is generally greater than light availability in streams.
- d. Agricultural grazing upstream will increase the light availability of a lake.

85. (1.5 pts) Two neighboring lakes, Lake A and Lake B, have the same average depth. Lake A has a larger surface area and length than Lake B. Which lake will have larger waves, on average?

Briefly justify your answer.

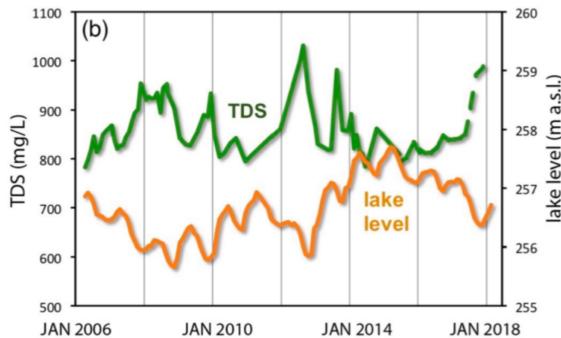
86. (0.5 pts) If two lakes have the same surface area, would mixing be more effective in a shallower or deeper lake?

- a. Shallower
- b. Deeper
- c. Neither; both would have equal mixing

87. (1 pt) Compared to non-tidal waves on a lake, tidal waves generally have a \_\_\_ wavelength and a \_\_\_ amplitude.

- a. longer; higher
- b. longer; lower
- c. shorter; higher
- d. shorter; lower

88. (1 pt) Consider the following graph of TDS (total dissolved solids) versus lake level.

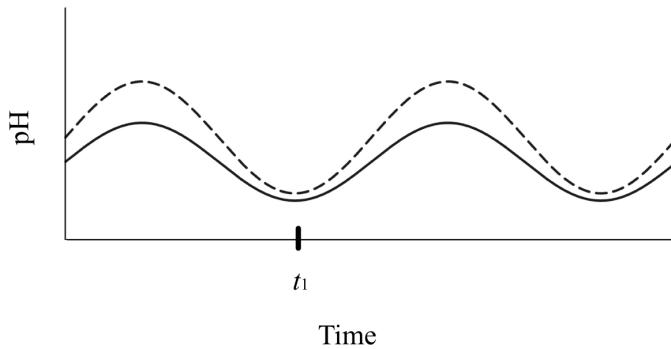


(Frondini et al., 2019)

Which of these statements can be inferred from the graph, if any?

- I. The lake is primarily fed by groundwater rich in ions
  - II. TDS levels are elevated during years with below-normal precipitation
- 
- a. I, only
  - b. II, only
  - c. I and II
  - d. Neither

Consider the following graph of pH versus time for a lake with some aquatic plants and algae. The two curves correspond to different layers of the lake.

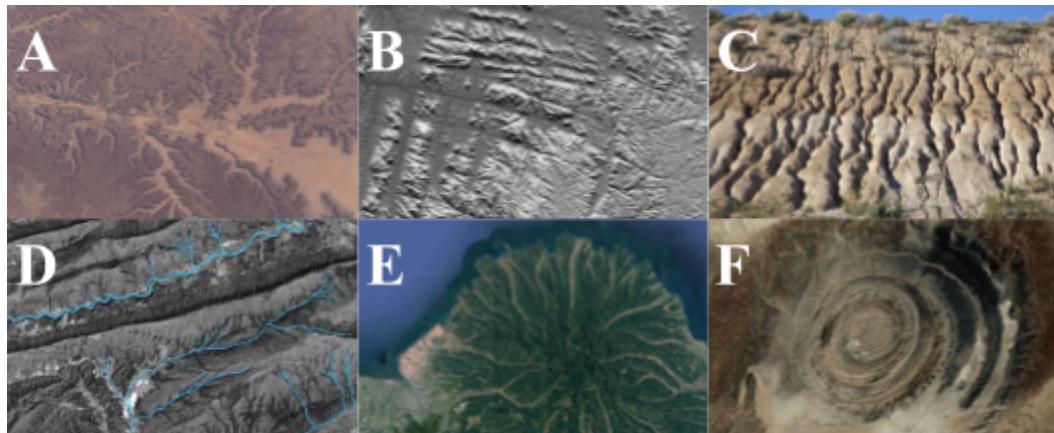


89. (0.5 pt) The period of the graphs is approximately 1 day. During what time of day does time  $t_1$  correspond to?

- a. Early evening
- b. Just before sunrise
- c. Noon

90. (1.5 pt) Does the dotted curve correspond to pH fluctuations in the limnetic zone or profundal zone? Briefly justify your answer.

## Section 9: Drain Age (11 pts)



(0.5 pt each) For questions 91-98, write the **capital letter** of the image corresponding to the following drainage patterns. If the drainage pattern is not among the images, write “N”.

91. Annular

92. Dendritic

93. Parallel

94. Radial

95. Deranged

96. Rectangular

97. Centripetal

98. Trellis

(1 pt each) For questions 99-101, write the capital letter of the image corresponding to the drainage pattern that would form in the described environment. If the drainage pattern is not among the images, write “N”.

99. Nepal’s Kathmandu Valley contains a circular basin where tributaries of the Bagmati River converge.

100. The steep escarpments found in Chambal Valley, Rajasthan are composed of weak substrate that is devoid of vegetation. The landscape that forms from erosion in this region is referred to as badlands topography.
101. Mount Rainier is an active stratovolcano found in the state of Washington, largely composed of andesite.
102. (1 pt) Compared to the drainage pattern in Image C, the drainage pattern in Image A tends to form on \_\_\_\_ slopes.  
a. steeper  
b. gentler  
c. equally steep
103. (1 pt) What term would describe a stream that forms a dendritic pattern as it flows through alternating bands of resistant and less-resistant bedrock?  
a. Accordant  
b. Antecedent  
c. Deranged  
d. Divergent  
e. Nonconforming
104. (1 pt) The stream order is \_\_\_\_ at the center of a radial drainage basin and \_\_\_\_ at the center of a centripetal drainage basin.  
a. high, high  
b. high, low  
c. low, high  
d. low, low
105. (1 pt) A ridge in the North American Cordillera separates the watershed of the Atlantic Ocean from that of the Pacific Ocean. What is the term to describe this type of boundary?

## **Section 10: Channel 10 News (10 pts)**

(0.5 pt each) For questions 106-115, indicate whether the statement is true or false.

106. Water flowing in the hyporheic zone of a stream channel tends to flow faster than it does in the open channel.
107. For an ephemeral stream, the water table is below the stream channel.
108. In a region where a river transitions from flowing over more resistant bedrock to less resistant bedrock, a nickpoint is likely to form after some time.
109. During a flood, the competence of a stream increases while its capacity remains the same.
110. For a meandering stream, the thalweg is closer (in terms of horizontal distance) to the cut bank than the point bar.
111. In a straight channel stream, the greatest flow velocity in a stream tends to be near the bed of the channel.
112. Potholes are often formed in the sections of a stream that exhibit laminar flow.
113. The implementation of flood-control dams would cause the floodplain to erode.
114. As stream velocity increases, sand is usually the first to be eroded before clay.
115. A river system in dynamic equilibrium means that it is not subject to disturbances or perturbations that may affect its flow.
116. (2 pts) [TB7] A student calculates the sinuosity of a certain stream to be 0.45. How can one immediately tell that this value is unreasonable? Why is this answer not physically possible?

For questions 117-119, consider the following topographic map with numbered streams.



1            2            3

117. (1 pt) Complete the following statement: in the future, stream \_\_\_\_ will be the most likely to capture or pirate stream \_\_\_\_.

- a. 1; 2
- b. 1; 3
- c. 2; 3
- d. 2; 1
- e. 3; 1
- f. 3; 2

118. (1 pt) Briefly justify your answer to the previous question.

119. (1 pt) Identify the number of drainage divides shown in the map (before stream capture) and after stream capture.